

7 CONTAMINATION TESTING RESULTS

The proposed development of the site is to involve the construction of residential units with associated soft landscaping, parking and access roads. The chemical samples were generally retrieved in line with BS ISO 18400-105:2017 *Soil Quality. Sampling*. The chemical results are presented in Appendix C.

7.1 Site Characterisation

Within the Solmek Phase 1 Desk Study, a preliminary conceptual model was formed based on the information obtained. The initial risk was based on the site history which recorded multiple developments over the site's history.

An overall very low to high risk was provided for various receptors:

- Human Health – Moderate/Low
- Controlled Water – Moderate to Very Low
- Current Site Users (on-site workers/visitors) – Moderate/Low
- Vegetation – Moderate/Low
- Construction Materials – Moderate/Low

7.2 Contamination Testing and Rationale

To provide information upon the possibility of ground contamination five samples of made ground and one samples of natural clay were selected for shallow contamination testing. A Moderate to Low overall contamination risk was highlighted in the Phase 1 Desk Study due to previous land uses. This coupled with the end use being Residential with Home Grown Produce means that six samples are considered appropriate for testing. The samples selected are detailed below:

- BH01 – 0.10-0.60m (Made ground – granular)
- BH02 – 0.00-1.00m (Made ground – granular)
- BH03 – 3.00-4.00m (Natural Clay)
- BH04 – 0.00-1.00m (Made ground - granular)
- CP01 – 1.00-1.40m (Made ground - granular)
- CP02 – 2.00-2.50m (Made ground - granular)

The samples selected are considered to provide coverage of both the made ground and shallow natural strata from across the site that would be most likely to be exposed during future site works. The samples were tested for the following contaminant suites:

- 6no Metals, semi-metals, non-metals, inorganic determinants
- 3no Asbestos identification screenings
- 6no Speciated Polyaromatic Hydrocarbons (PAHs)
- 3no Total Petroleum Hydrocarbon Criteria Working Group fractions (TPHCWG)

Furthermore, another five samples of both made and natural ground were tested for pH and soluble sulphates to assess risk to construction materials. The samples selected are summarised below:

- BH01 – 3.20-4.00m (Natural clay)
- BH02 – 1.40-2.00m (Made ground – cohesive)
- BH03 – 1.00-2.00m (Natural clay)
- CP01 – 12.00-13.00m (Natural clay)
- CP02 – 4.00-4.50m (Natural clay)

7.3 Test Results

Based on the proposed development at the site, the test results have been compared to a series of Land Quality Management (LQM) Suitable for Use Levels (S4UL) based on a residential with home grown produce land use. These are the most up to date thresholds published in 2015.

The value for lead has been compared with the Category 4 Screening Level (March 2014) developed by Contaminated Land: Applications In Real Environments (CL:AIRE).

The test results are presented in Appendix C, and a summary is provided below in Tables 2 & 3.

TABLE 2: SUMMARY OF INORGANIC CONTAMINATION TESTING RESULTS

Determinand	Units	Number of Samples above Level of Detection	Minimum Recorded Level	Maximum Recorded Level	Residential with HGP Threshold Value	Number of Results Exceeding Threshold Value
Metals						
Cadmium	mg/kg	0	<0.1	0.1	11	0
Chromium	mg/kg	6	9.1	77	910	0
Copper	mg/kg	6	5.5	40	2400	0
Lead	mg/kg	6	5	44	200*	0
Mercury	mg/kg	0	<0.1	-	40	0
Nickel	mg/kg	6	5.6	42	180	0
Zinc	mg/kg	6	17	79	3700	0
Semi metals and non metals						
Arsenic	mg/kg	6	2.5	26	37**	0
Boron	mg/kg	4	<0.4	1.8	290	0
Selenium	mg/kg	0	<0.2	-	250	0
Inorganic chemicals						
Cyanide (Total)	mg/kg	0	<0.5	0.5	1.49**	0
Sulphate (2:1 Water Soluble)	mg/l	11	43	340	2000^	0
Other						
pH	pH	-	8.5	12.2	5.5^	0
* Category 4 Screening Levels, March 2014 ** CLEA Software Version 1.06 (pH7 and 1%SOM) ^ EA Threshold Values HGP Home Grown Produce						

7.4 Metals, Semi Metals and Non Metals

None of the six samples tested indicated significant raised levels of contamination above the S4UL threshold values.

7.5 Inorganic Chemicals

Soluble sulphates (potentially aggressive to foundation concrete) were recorded between 43 and 340mg/l. None of the samples were elevated above levels affecting human health or the BRE Special Digest 1 500mg/l limit for the sulphate classification of concrete.

The results of the pH testing were between 8.5 and 12.2. These pH levels are consistent with alkaline conditions.

7.6 Organic Chemicals

The organic thresholds vary depending on the levels of soil organic matter (SOM).

The average SOM recorded across the site was 0.40% therefore a SOM of 1.00% has been used to determine the S4UL thresholds. Table 3, below, summarises the results.

TABLE 3: SUMMARY OF ORGANIC CONTAMINATION TESTING RESULTS

Determinand	Units	Number of Samples above Level of Detection	Minimum Recorded Level	Maximum Recorded Level	Residential with HGP Threshold Value at 1% SOM	Number of Results Exceeding Threshold Value
TPH Aliphatic Fractions						
Aliphatic (C5-C6)	mg/kg	0	<0.01	-	42	0
Aliphatic (C6-C8)	mg/kg	0	<0.01	-	100	0
Aliphatic (C8-C10)	mg/kg	0	<0.01	-	27	0
Aliphatic (C10-C12)	mg/kg	3	2.17	22.49	130	0
Aliphatic (C12-C16)	mg/kg	0	<1.20	-	110	0
Aliphatic (C16-C21)	mg/kg	0	<1.50	-	65000	0
Aliphatic (C21-C35)	mg/kg	2	<3.40	139.4	65000	0
Aliphatic (C35-C40)	mg/kg	2	<3.40	238.4	65000	0
TPH Aromatic Fractions						
Aromatic (C5-C7)	mg/kg	0	<0.01	-	70	0
Aromatic (C7-C8)	mg/kg	0	<0.01	-	130	0
Aromatic (C8-C10)	mg/kg	0	<0.01	-	34	0
Aromatic (C10-C12)	mg/kg	0	<0.90	-	74	0
Aromatic (C12-C16)	mg/kg	0	<0.50	-	140	0
Aromatic (C16-C21)	mg/kg	3	1.59	22.3	260	0
Aromatic (C21-C35)	mg/kg	2	<1.40	87.61	1100	0
Aromatic (C35-C40)	mg/kg	0	<1.40	-	1100	0
Speciated PAH						
Naphthalene	mg/kg	0	<0.1	-	2.3	0
Acenaphthylene	mg/kg	0	<0.1	-	170	0
Acenaphthene	mg/kg	0	<0.1	-	210	0
Fluorene	mg/kg	1	<0.1	0.11	170	0
Phenanthrene	mg/kg	3	<0.1	0.41	95	0
Anthracene	mg/kg	2	<0.1	0.23	2400	0
Fluoranthene	mg/kg	4	<0.1	0.58	280	0
Pyrene	mg/kg	3	<0.1	0.8	620	0
Benzo[a]anthracene	mg/kg	2	<0.1	0.43	7.2	0
Chrysene	mg/kg	1	<0.1	0.3	15	0
Benzo[b]fluoranthene	mg/kg	1	<0.1	0.37	2.6	0
Benzo[k]fluoranthene	mg/kg	1	<0.1	0.11	77	0
Benzo[a]pyrene	mg/kg	1	<0.1	0.64	2.2	0
Benzo[g,h,i]perylene	mg/kg	0	<0.1	-	27	0
Dibenz(a,h)Anthracene	mg/kg	0	<0.1	-	0.24	0
Indeno(1,2,3-c,d)Pyrene	mg/kg	0	<0.1	-	320	0
Total PAH	mg/kg	1	<2	3.5	50*	0
Total Phenol	mg/kg	0	<0.3	-	280	0
* EA Threshold Values						

None of the six samples tested indicated raised levels of contamination above the S4UL threshold values.

7.7 Asbestos

From the three samples subject to asbestos screening, asbestos fibres were recorded in none.

7.8 Environmental Protection Act 1990: Part 2A Revised Statutory Guidance (April 2012)

This revised document explains how the Local Authority should decide if land, based on a legal interpretation, is contaminated. The document replaces the previous guidance given in Annex 3 of DEFRA Circular 01/2006, issued in accordance with section 78YA of the 1990 Environmental Protection Act.

The main objectives of the Part 2A regime are to “identify and remove unacceptable risks to human health and the environment” and to “seek to ensure that contaminated land is made suitable for its current use”. Part 2A uses a risk based approach to defining contaminated land whereby the “risk” is interpreted as “the likelihood that harm, or pollution of water, will occur as a result of contaminants in, on or under the land” and

by “the scale and seriousness of such harm or pollution if it did occur”.

For a relevant risk to exist a contaminant, pathway and receptor linkage must be present before the land can be considered to be contaminated. The document explains that *“for a risk to exist there must be contaminants present in, on or under the land in a form and quantity that poses a hazard, and one or more pathways by which they might significantly harm people, the environment, or property; or significantly pollute controlled waters.”*

A conceptual model is used to develop and communicate the risks associated with a particular site.

To determine if land is contaminated the local authority use various categories from 1 to 4. Categories 1 and 2 include “land which is capable of being determined as contaminated land on grounds of significant possibility of significant harm to human health.” Categories 3 and 4 “encompass land which is not capable of being determined on such grounds”.

See Appendix D for additional notes on contamination guidelines.

8 CONCEPTUAL MODEL AND CONTAMINATION ANALYSIS

The contamination conceptual model in Table 4 identifies the potential pollution linkages present on site based on source – pathway – receptor relationships.

TABLE 4: CONCEPTUAL MODEL

Source	Pathway	Receptor	Risk Rating	Comments
Asphyxiating or explosive ground gases - Made ground (2.80m bgl) - Not in a Radon Affected Area	Ground gas migration - Migration through permeable soils - Inhalation	Future site users Adult & infant residents	Moderate /Low	Gas monitoring in progress, source risk rating subject to change.
		Users during development Construction workers	Low	
Areas of contamination hazardous to human health (Residential Thresholds) 6no samples tested - No significantly elevated organic determinants - No significantly elevated inorganic determinants - No asbestos	- Inhalation - Dust ingestion - Dermal contact	Future site users Adult & infant residents	Low	No significantly elevated contamination recorded from soil analysis.
		Users during development Construction workers	Low	
	- Inhalation - Dust ingestion	Users of surrounding sites Transient adult workers	Low	Low risk during remediation/construction from dust generation. However, as good practice, consideration to be given to dust suppression, in line with BRE: <i>The Control of Dust and Emissions from Construction and Demolition, Best Practice Guidance</i> .
		Drift geology Secondary – Undifferentiated	Low	
	Leaching of mobilised contaminants	Solid geology Secondary Aquifer - A	Low	Limited availability of contaminants recorded from soil analysis unlikely to affect this medium sensitivity aquifer.
Areas of phytotoxic contamination No phytotoxic contamination	- Drainage - Lateral migration - Accumulation of contaminated sediment - Uptake via roots and leaf surfaces	Surface water features River 461m northwest	Very Low	Very limited potential for contamination from site to reach surface water, either via surface runoff or groundwater movement.
		Vegetation Gardens proposed	Low	No phototoxic levels of contamination recorded from soil analysis.
Areas of contamination above service fabric or BRE Special Digest 1 thresholds Elevated pH	Direct contact	Construction Materials Concrete	Moderate /Low	Mitigation through use of sulphate resistant concrete where in contact with made ground. Concrete to be designed to class DS-1 ACEC (AC-1), assuming mobile groundwater conditions.
		Construction Materials Service Fabric	Moderate /Low	Copper piping to be avoided and prudent to lay any service within a clean bedding.

In general terms, construction materials are **potentially most** at risk as pollution linkages may be present for each of these receptors. Users of the site, users of the surrounding sites, vegetation, construction workers and controlled waters are considered to be at **potentially less** of a risk.

Mitigation measures to reduce the risks identified for each receptor are discussed in the following sections.

8.1 Users of the Site Once Development is Complete

The users of the site, particularly residents, are likely to be exposed to contaminants present in the soils beneath the site during redevelopment work. **Potential** exposure pathways include dermal absorption after contact with contaminated ground, inhalation of soil or dust, inhalation of volatilised compounds, and inadvertent soil ingestion.

To establish if the levels of contaminants present on site may pose a risk to the health of the future users of the site the results of the contamination testing have been compared to a series of LQM S4UL thresholds based on commercial end use (see Tables 2 & 3).

The levels of contaminants across the site are generally low with no significant exceedances recorded from the six samples tested.

8.2 Construction Workers and Users of Surrounding Sites

Short term human exposure to contaminants present in soils can occur via several pathways during the construction and ground works phase of the development. These include dermal absorption after contact with contaminated ground, inhalation of soil or dust (including windblown dust), inhalation of volatilised compounds, inadvertent soil ingestion and contact with contaminated groundwater.

As good practice, full PPE must be employed in accordance with Health and Safety Executive: *Protection of Workers and the General Public During the Development of Contaminated Land* and safeguards should be taken to limit dust during ground works, and access to the public should be restricted. Construction workers should use gloves as a precaution when handling any fill materials. Provision of suitable hygiene facilities are needed for site workers. Wheel washers could be provided and used for any vehicle entering or leaving site to prevent cross contamination.

Although asbestos or other forms of contamination were not detected from the soil samples subjected to testing within this investigation, the possibility still exists that asbestos containing materials may still be present on site and currently lie undetected. It is therefore advised that a 'watching brief' is undertaken during the initial site strip and any excavation works and advice sought if asbestos is found or suspected.

During dry weather, any excavations may require clean water to be sprinkled at shallow depth to prevent excess dust escaping to off-site receptors. Monitoring of dust concentrations during construction should be given careful consideration to ensure occupational exposure levels are not exceeded. Works should be undertaken in line with BRE: *The Control of Dust and Emissions from Construction and Demolition, Best Practice Guidance*.

8.3 Vegetation

Plants can be affected by soil contamination in a number of ways resulting in growth inhibition, nutrient deficiencies and yellowing of leaves. Contaminants are taken up by plants through the roots and through foliage. Contaminants identified as being highly phytotoxic include boron, cadmium, copper, nickel, and zinc.

To establish if the levels of contaminants present on site may pose a risk to vegetation the results of the contamination testing have been compared to a series of threshold values published in *Code of Good Agricultural Practice for the Protection of Soil*. No concentrations of the phytotoxic determinants are shown as elevated from the four samples tested.

8.4 Ground and Surface Water

The principal pathway by which soil contamination may reach the water environment is through a slow seepage or leaching to groundwater or surface water. The potential for contaminants to migrate along such pathways is dependent on the chemical and physical characteristics of the contaminants and the local

hydrogeology.

8.4.1 Hydrogeological Context

From the site investigation undertaken, ground conditions broadly comprise deep made ground (2.80m bgl) over drift deposits comprising stiff to hard clays (low permeability) with interbedded sands (moderate to high permeability). The drift deposits are designated as a Secondary Aquifer – undifferentiated by the Environment Agency.

The published geology indicates the site is underlain by solid geology of the Mercia Mudstone Formation, which is designated as a Secondary Aquifer - A by the Environment Agency, but is not within a Source Protection Zone. Rockhead was not proven during the intrusive investigation.

The nearest surface water feature is Battling Brook, located 461m northwest of the site.

With respect to groundwater, during the fieldwork shallow strikes were noted a 4.60m bgl within the natural sand.

The groundwater flow onsite is likely to be northwest, towards Battling Brook.

A number of groundwater and surface water abstractions are located within 1km of the site. The nearest is a groundwater abstraction located 200m west of the site.

8.4.2 Contamination Context

No significant contamination was recorded based on the six soil samples tested.

8.4.3 Hydrogeological Risk Assessment

Due to the generally low contamination found across the site, the aquifer designations beneath the site, and the distance to surface waters, the development is considered to represent a low risk to groundwater and surface water receptors.

8.5 Construction Materials

Materials at risk from potential soil contamination include inorganic matrices such as cement and concrete and also organic material; e.g. plastics and rubbers. Acid ground conditions and elevated levels of sulphates can accelerate the corrosion of building materials. Plastics and rubbers are generally used for piping and service ducts and are potentially attacked by a range of chemicals, most of which are organic, particularly petroleum-based substances. Drinking water supplies can be tainted by substances that can penetrate piping and water companies enforce stringent threshold values.

8.5.1 Concrete Classification

BRE Special Digest One: *Concrete in Aggressive Ground*: 2005 3rd Edition has been used to assess the risks posed to underground concrete and to establish the design measures required to mitigate the risks. The results of the pH and water-soluble sulphate tests (when converted to total potential sulphate) fall into Class DS-1 ACEC (Class AC-1) requirements for concrete protection. This assumes mobile groundwater conditions.

8.5.2 Water Supply Pipes Material Selection

The levels of potential contaminants should be compared to thresholds supplied in the UK Water Industry Research (UKWIR) publication *Guidance for the selection of Water Supply Pipes to be used in Brownfield Sites* (January 2011). A Brownfield Site is defined in the document as “Land or premises that have previously been used or developed that may be vacant or derelict”. It should be noted that Brownfield sites may not be contaminated. The guidance does not apply to Greenfield Sites however water companies may have their own assessment criteria which should be checked by the developer.

Based on the samples tested during the site investigation, levels of acidic to alkaline pH (8.5 to 12.2) were recorded across the site at depths of between 0.00mbgl and 13.00mbgl within the made ground and natural

samples.

The concentrations of the selected determinants should be compared to the pipe material selection table in Appendix D, and consultation with the appropriate utility supply company is required to identify the most suitable service fabric. However, the pH levels may preclude the use of copper pipes depending on the depth of proposed service corridors.

8.6 Unexpected Contamination

If during the initial site strip or subsequent ongoing construction activities, any zones of odorous, brightly coloured or suspected contaminated ground, or suspected Asbestos Containing Materials (ACMs) are encountered, then the following procedure should be followed:

- Stop work in the affected area
- Contact Solmek and provide pictures of the affected area
- Solmek can visit site to investigate the material and provide guidance
- If required – Solmek can sample and test the material
- Once test results are returned, this will determine whether or not remediation will be required

8.7 Waste Classification

During the site strip and construction activities, material may be required to be removed from site. Any such material would require classification, in line with Environment Agency Technical Guidance *Waste Classification: Guidance on the classification and assessment of waste* (2015). This would classify the material as either Non-Hazardous or Hazardous Waste.

Once the material has been classified, determining the suitable landfill for disposal is governed by landfill directive Waste Acceptance Criteria (WAC) testing, with landfills categorized as Inert Waste, Stable Non-Reactive Hazardous Waste and Hazardous Waste.

If waste classification and/or WAC testing are not undertaken, material taken off site may be subject to WAC testing by the appropriate waste disposal company. The decision on whether or not to accept waste, or whether further testing is required, is at the discretion of the waste disposal company.

For this project, WAC testing was requested. We are still awaiting the results of the testing. This report will be updated with the results of the testing and reissued.

9 GROUND GAS ASSESSMENT

The proposed development includes the construction of residential housing.

Ground gases such as carbon dioxide (CO₂), methane (CH₄), carbon monoxide (CO) and volatile organic compounds (VOCs) can be classed as a form of contamination where there is a potential risk to human health.

For this report, gas monitoring is via measuring emissions from three standpipes (BH01, BH03 & CP01) that were installed during the sitework. The gas monitoring will consist of six visits over a period of three months. The gas monitoring results will be presented as an addendum to this report.

9.1 Monitoring Wells and Response Zones

During the site investigation works, gas/groundwater monitoring wells were installed within five boreholes. The response zones are briefly summarised below in Table 5.

TABLE 5: SUMMARY OF MONITORING WELL RESPONSE ZONES

Borehole	Pipework	Installation Depth (mbgl)	Response zone of slotted pipework (mbgl)	Response Zone Stratum
BH01	50mm HDPE pipe	3.00	2.00-3.00	NATURAL CLAY
BH03	50mm HDPE pipe	3.00	1.50-3.00	NATURAL CLAY/SAND
CP01	50mm HDPE pipe	2.00	1.00-2.00	MADE GROUND

10 GEOTECHNICAL TESTING AND ANALYSIS

Samples taken from the boreholes and trial pits underwent a series of geotechnical tests at a UKAS accredited laboratory to aid foundation design and soil description. In addition, in-situ Standard Penetration Tests (SPTs) were undertaken at regular intervals during drilling. The geotechnical results are presented in Appendix D.

We are still awaiting results from the geotechnical laboratory testing. This report will be updated and reissued upon receiving the results.

10.1 Strength and Density

10.1.1 SPT N Values

Standard Penetration Tests undertaken within the natural granular deposits yielded N values of between 19 and 50+ (refusal), indicative medium dense to very dense deposits.

Standard Penetration Tests undertaken within the natural cohesive deposits yielded N values of between 12 and 50+ (refusal). These N values can be correlated to provide approximate shear strengths, with these results indicating medium to very high strength deposits.

10.2 Foundations

10.2.1 Conventional Foundations upon Cohesive Deposits

It should be assumed that cohesive deposits on site are of high volume change potential. Foundations should therefore be placed at a minimum depth of 1.0m below original or finished ground level, whichever is the lower.

Locally, foundations will require deepening to 3.00m bgl due to made ground depths. All deepened sections should be adequately stepped, in accordance with NHBC Standards Chapter 4.4.

A series of safe bearing capacities have been calculated for strip foundations 0.60m wide, founding at depths between 1.00m and 3.00m bgl. The results are summarised below in Table 6:

TABLE 6: SUMMARY OF SAFE BEARING CAPACITIES

Depth (m bgl)	Foundation Width (m)	Strata	Shear Strength (kN/m ²)	Safe Bearing Capacity (kN/m ²)	Settlement (mm)
1.20	0.60	Stiff Medium Strength CLAY	60	120	<25
2.00	0.60	Very stiff High Strength CLAY	100	200	<25
3.00	0.60	Very stiff High Strength CLAY	75	160	<25

It should be recognised that clay rich soils can deteriorate fairly rapidly on exposure, particularly in periods of wet weather and frost. It would be prudent to protect all exposed soils in foundation excavations with a concrete blinding layer, particularly if they are likely to remain open for extended period of time.

10.2.2 *Piled Foundations*

Given the depth of made ground across the site, consideration could be given to piled foundations. Information provided in this report should be made available to a competent piling contractor who can design appropriate foundations in accordance with Section 7: Pile foundations of BS EN 1997 – 1:2004 which applies to end-bearing piles, friction piles, tension piles and transversely loaded piles installed by driving, by jacking, and by screwing or boring. The piling contractor will need to take into consideration the possible effects of negative skin friction from made ground. Allowance should be made for breaking through known and unknown buried obstructions.

The precise method of pile installation and the applicability of proprietary systems, diameters and depths required would need to be determined by a specialist piling contractor.

10.2.3 *General Foundation Comments*

It is recommended that an adequate drainage system for surface water be installed by a competent contractor in order to prevent surface water ponding or collecting during and post construction, which may in turn lead to deterioration of the founding stratum.

Prior to placing foundation concrete, obvious soft or loose spots should be removed and replaced with suitably recompacted hardcore or lean mix concrete. In addition, all excavations should be inspected to ensure that they fully penetrate areas of disturbed ground.

Further advice should be sought from Solmek if unexpected ground conditions are encountered during redevelopment.

10.2.4 *Ground Slabs*

Made ground is in excess of 600mm and a suspended reinforced ground slab or precast concrete floor should therefore be used. However, if the made ground was removed from beneath the foot print of the building and a blanket of compacted inert granular fill was placed in accordance with an engineering specification, ground bearing slabs may be possible, if applicable.

10.2.5 *Roads and Parking*

Where granular made ground is recompacted a CBR of at least 5% however should be achievable, however this should be verified by insitu CBR testing on site and confirmed with the adopting authority.

10.3 **Excavation**

Based on the nature of the ground conditions encountered, excavations should be within the capacity of normal earthworks plant although breaking out of obstructions should be anticipated. Stability of excavations will be poor in the made ground but should improve in the natural clay. Excavation sides should be designed, constructed and supported in accordance with the recommendations given in CIRIA Report No. 97: "Trenching Practice".

10.4 **Groundwater**

Groundwater was encountered at 4.60m bgl, as referenced in Table 1.

It should be noted the rapid rate of advancement of the exploratory holes may mask minor seepages and it should be borne in mind that water levels fluctuate with a number of influences including season, rainfall, dewatering and pumping activities. Therefore, water levels significantly higher than those found during this investigation may be encountered. Significant dewatering may be required based on the groundwater encountered during the intrusive investigation.

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